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November 10, 2004

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## PRIORITY DOCUMENT

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Date: 10/14/03

22386 U.S. PTO  
10/683269

10/14/03

Dear Sir:

Transmitted herewith for filing is the **UTILITY** patent application of:

Inventor(s): Shota MURAKAMI &amp; Tsuyoshi YOSHIDA

Title: PIN ASSEMBLY FOR TRACK ROLLER BOGEY OF TRACK-TYPE DRIVE SYSTEM

- ☒ 18 pages of written description, claims and abstract.  
☒ FIVE sheet(s) of formal drawings.  
☒ Executed Declaration and Power of Attorney  
☒ Assignment Papers (cover sheet and documents)  
☐ Certified Copy of Priority Documents  
☒ Information Disclosure Statement  
☒ Return Postcard Receipt  
☐ Preliminary Amendment

- ☐ Nucleotide and/or Amino Acid  
Sequence Submission including:  
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☐ Other: \_\_\_\_\_☒ Filing Fee, calculated as shown below:

	(Col. 1)	(Col. 2)
FOR:	NO. FILED	NO. EXTRA*
BASIC FEE		
TOTAL CLAIMS	6 - 20 =	0
INDEP. CLAIMS	2 - 3 =	0
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIMS PRESENTED		

\* If the difference in Col. 1 is less than zero, enter "0" in Col. 2

## SMALL ENTITY

RATE	FEE
	\$ 385.00
x 9	\$
x 43	\$
+ 145	\$
TOTAL	\$

OR

OR

OR

OR

OR

OTHER THAN A  
SMALL ENTITY

RATE	FEE
	\$ 770.00
x 18	\$
x 86	\$
+ 290	\$
TOTAL	\$ 770.00

- ☐ Applicant claims small entity status. See 37 CFR 1.27.  
☐ One check ☒ two checks in the amount of \$ 770.00 & 40.00 to cover the filing fee and  
☐ assignment recordation is (are) enclosed.  
☒ The Commissioner is hereby authorized to charge and credit our Deposit Account No. 22-0256 as  
described below. A duplicate of this sheet is attached.  
☐ Charge the amount of \$ \_\_\_\_\_ to cover the filing fee and ☐ assignment recordation.  
☒ Charge deficiencies in the enclosed fees or any additional filing fees required under 37 CFR 1.16.  
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☐ Charge the issue fee set in 37 CFR 1.18 at the mailing to the Notice of Allowance pursuant to  
37 CFR 1.311(b).  
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DIRECT ALL CORRESPONDENCE TO:

VARNDELL & VARNDELL, PLLC  
106-A South Columbus Street  
Alexandria, VA 22314  
(703) 683-9730

Customer Number  
021369 →

021369

PATENT TRADEMARK OFFICE

Respectfully submitted,  
VARNDELL & VARNDELL, PLLC

*R. Eugene VarndeLL*  
R. Eugene VarndeLL, Jr.  
Registration No. 29,728



## TITLE OF THE INVENTION

PIN ASSEMBLY FOR TRACK ROLLER BOGIE OF TRACK-TYPE DRIVE SYSTEM

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a pin assembly, and more particularly to a pin assembly for pivoting a track roller bogie (hereinafter, refer simply to a bogie) of a track-type drive system.

### 2. Description of the Prior Art

The track-type drive system corresponds to a system driving a vehicle by driving a track connecting links having track shoes in an annular shape by pins by means of a sprocket. The drive system mentioned above has a larger ground contact area in comparison with a drive system employing wheels, and is mainly used in a vehicle driving on a rough ground, a snow ground, a weak ground, a battlefield, a civil work field and the like.

A typical track-type drive system is shown in Fig. 1. An idler 2 is pivoted to one end of a track frame 1 swingably attached to a vehicle body, and a sprocket 3 is pivoted to the vehicle body in a direction of another end. A bogie 4 provided with a track roller 5 is mounted to a lower side of the track frame 1. In general, the track



roller or the bogie provided with the track roller is mounted to the track frame in accordance with one type that a position of the track roller is fixed, or another type that the track roller is mounted so as to vertically swing. Fig. 1 shows a bogie of the latter type that the track roller is mounted so as to freely swing. A crawler belt 6 is wound around a periphery of the idler 2, the track roller 5 and the sprocket 3. In accordance with this type, since the track roller 5 can follow to a vertical motion of the crawler belt 6, it is possible to more stably ground the vehicle.

Fig. 4 shows a structure cited from U.S. Pat. No. 6,607,256, and shows details in the periphery of the pivotally supported portion of the bogie 4 to the track frame 1 in the swing-type bogie as shown in Fig. 1. The bogie 4 in these drawings is constituted by a first bogie link 8 and a second bogie link 23. First, another end of the first bogie link 8 is bifurcated, and the bifurcated portions are respectively pivoted to the track frame 1 by pins 14. A second bogie link 23 is rotatably mounted to one end of the first bogie link 8, and the track roller 5 is mounted to an end portion of the second bogie link so as to freely roll.

Viewing the pivotally supported portion of the first bogie link 8 to the track frame 1 in detail, a pair of



left and right brackets 7 and 7 are arranged on an underside of the track frame 1, and an opening portion is provided in each of the brackets. A first ring 9 and a third ring 11 are fixed respectively to inner peripheries of the opening portions in a pair of left and right brackets. The pins 14 are fixed to inner peripheral portions of the first ring 9 and the third ring 11. A second ring 10 is annularly provided between the first ring 9 and the third ring 11 in such a manner as to freely rotate with respect to the pin 14. Another end of the first bogie link is bifurcated in correspondence to a pair of left and right brackets 7 and 7, and an outer periphery of the second ring 10 is fixed to an opening portion existing in the branch portion.

In this case, it is necessary to lubricate a rotating portion between the second ring 10 and the pin 14, and a slide contact portion among the first, second and third rings by using a lubricant, however, is sealed from an outer portion for the purpose of preventing the lubricant from leaking to the external portion and the purpose of insuring the rotating portion and the slide contact portion against soil grains such as sands, silts and the like. Fig. 5 is an enlarged view around the rotating portion and the slide surface between the second ring 10 and the third ring 11. For the purpose of the sealing mentioned



above, annular recess portions are provided in positions opposing to contact surfaces of the respective rings, and a pair of left and right face seals 15 and 15 are inserted thereto. The face seals 15 and 15 are pressure contacted by O-rings 16 and 16 so as to prevent a lubricating oil supplied via a lubricant passage 17 from flowing out to an outer portion of the pivotally supported portion together with the O-rings 16 and 16, and prevent the soil grains from making an intrusion into the rotating portion and the sliding surface from the outer portion.

Further, spacers 13 formed as a ring having a rectangular cross sectional shape are slidably arranged in inner sides of the face seals 15 and 15 in a radial direction so as to be slidable with respect to each of the second ring 10, the third ring 11 and the pin 14 in a contact state therewith. The spacer 13 is provided for the purpose of transmitting a load in a thrust direction generated in the case that a drive surface is unevenly brought into contact with the track shoe with keeping a level difference in a lateral direction (a lateral direction in Fig. 4) of the track shoe, between the first ring 9 and the second ring 10.

The sealing and lubricating functions required in the contact portion among the first, second and third rings are achieved by the structure of the pivotally supported



portion mentioned above, however, since the contact portion requires totally ten parts comprising a pair of face seals, a pair of O-rings and the spacers, it is troublesome to assemble them. Further, in the spacer, it is necessary to lubricate all the outer peripheral surface thereof, however, since the cross sectional shape is rectangular, the lubricating oil is hard to smoothly circulate around the outer surface, so that there is a problem that a service life of the parts is shortened due to seizure or the like. In other words, since a labyrinth is formed in the portion to be lubricated, there is a problem that a lack of lubrication may be generated. Further, in order to solve the problem, there can be considered a method of improving a lubricating property by making the spacer by a porous material such as a porous cast iron or the like, however, in this case, there is a problem that a manufacturing cost is increased.

#### SUMMARY OF THE INVENTION

The present invention is made by taking the circumstances mentioned above into consideration, and an object of the present invention is to provide a pin assembly which can more easily assemble a pivotally supported portion and solves the problem of the lack of lubrication caused by the rectangular spacer, and a track-type drive



system which employs the pin assembly.

In order to achieve the object mentioned above, in accordance with the present invention, there is provided a pin assembly for a bogie of a track-type drive system, comprising:

a pin having a lubricant charging hole and a lubricant delivering hole delivering the lubricant from the lubricant charging hole to an outer peripheral portion in an inner portion thereof;

a first ring having a contact surface with the pin in one end so as to be firmly attached to the pin and having an outer diameter  $D_1$ ;

a second ring brought into contact with another end side of the first ring in an axial direction of the pin so as to be rotatably pivoted to the pin and having an outer diameter  $D_2$ ; and

a third ring brought into contact with another end side of the second ring in an axial direction of the pin so as to be firmly attached to the pin and having an outer diameter  $D_3$ ,

wherein a part of a ring end surface contacted among the first, second and third rings has an annular recess portion, and the annular recess portion consists of a sealing means between rings for sealing therebetween, and the outer diameters  $D_1$ ,  $D_2$  and  $D_3$  have a relation  $D_1 < D_2$



< D<sub>3</sub> .

Further, in accordance with the present invention, there is provided a pin assembly, wherein the slide portion among the first ring, the second ring and the third ring is constituted by a slide contact surface with which each of the rings is directly contacted, and a seal surface of the sealing means in correspondence to each of the slide contact surfaces, and the slide contact surface and the seal surface form a substantially one flat plane in a radial direction.

In accordance with another invention, there is provided a track-type drive system comprising:

a bogie having a track frame, an idler, a sprocket, a carrier roller and a track roller and pivoted to the track frame; and

a crawler belt wound around them,

wherein the bogie is pivoted to the track frame by the above pin assembly.

In accordance with the other invention, there is provided a track-type drive system comprising:

a bogie having a track frame, an idler, a sprocket, a carrier roller and a track roller and pivoted to the track frame; and

a crawler belt wound around them,

wherein the bogie is constituted by a first bogie



link pivoted to the track frame, and a second bogie link pivoted to the first bogie link and to which the track roller is mounted, and

wherein the second bogie link is pivoted to the first bogie link by the above pin assembly.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view showing a general track-type drive system;

Fig. 2 is a cross sectional view of a pin assembly in accordance with the present invention;

Fig. 3 is a schematic view of an assembly of a pivotally supported portion of the bogie in accordance with the present invention;

Fig. 4 is a cross sectional view of a conventional bogie; and

Fig. 5 is an enlarged view of a part of a conventional pivotally supported portion of the bogie.

#### DETAILED DESCRIPTION OF THE INVENTION

A description will be given of a particular embodiment of a pin assembly in accordance with the present invention, and a pivoting structure using the same.

Fig. 2 shows a cross sectional view of a pin assembly in accordance with the present invention, and Fig. 3 shows



a schematic view of an assembly of a pivotally supported portion of the bogie of a track-type drive system achieved by the pin assembly.

A pin 14 is made of a carbon steel, and has a concentric cylindrical hole open in a left side of the pin 14 in Fig. 2. A right side of the hole is formed as an opening having a small diameter, and is closed by a detachable lid. A left side of the pin 14 is pressure inserted to a first ring 9 closing one end (a left side) of the opening so as to form a contact surface 24 with the pin 14, and strikes a right side of the contact surface 24. The cylindrical hole within the pin 14 strikes the contact surface 24, thereby forming the lubricant charging portion 19, and a lubricant such as a lubricating oil, a grease or the like is charged from a small-diameter opening arranged in a right side of the pin 14.

A second ring 10 is rotatably pivoted to the pin 14 in adjacent to a right side of the first ring 9. Since the first ring 9 is fixed to the pin 14, a slide portion 21 is formed between both the elements in accordance with a rotation of the second ring 10. The slide portion 21 is constituted by three parts. First, a slide contact portion 26 in which the first ring 9 is directly brought into contact with the second ring 10 is provided in a portion closest to a inner diameter side of the slide portion 21



in a radial direction. The slide contact portion 26 forms one flat surface in a radial direction. Since the first ring 9 and the second ring 10 are manufactured by the same material (for example, a chrome molybdenum steel), a surface hardening treatment such as a carburizing and quenching or the like is applied to a portion forming the slide contact surface 26 for the purpose of preventing a seizure. Further, the lubricant is supplied from the lubricant charging portion 19 mentioned above via the lubricant delivering hole 18 and the lubricant passage 17.

A sealing means having a sealing surface 28 for sealing the lubricant is provided in an outer diameter side of the slide contact surface 26. The sealing means is constituted by a pair of right and left face seals 15 and 15 and O-rings 16 and 16. These are clamped by annular recess portions provided in portions corresponding to the first ring and the second ring, and the face seals 15 and 15 are opposed to each other so as to form a contact surface corresponding to the sealing surface 28. The sealing surface 28 is placed on substantially the same plane as the slide contact surface 26.

An outer peripheral surface in which the first ring 9 and the second ring 10 are opposed to each other by an interval about 1 mm is formed in an outermost side of the



slide portion 21. A pressing force of the O-ring is set small such that a force is transmitted mainly by the slide contact surface 26 in the case that a load is applied in a thrust direction in the slide portion 21. In the prior art mentioned above, the spacer receiving the load in the thrust direction is interposed, however, in the present invention, the load in the thrust direction is transmitted directly by the slide contact surface 26 between the rings. In other words, as the constituting parts interposed between the rings, there is only provided with a sealing means constituted by a pair of O-rings and face seals.

The third ring 11 is pressure inserted to the pin 14 in the same manner as the first ring 9. A slide portion 22 between both the rings has the same structure as that of the slide portion 21 mentioned above, and has only a sealing means 30 constituted by a pair of O-rings 16 and 16 and face seals 15 and 15, and a sealing surface 29 formed by the sealing means and a slide contact surface 27 between both the rings are positioned on the same flat plane.

Further, the first ring 9, the second ring 10 and the third ring 11 have respective diameters  $D_1$ ,  $D_2$  and  $D_3$ , and have a relation  $D_1 < D_2 < D_3$ . In accordance with the structure mentioned above, it is possible to easily fit to a member pivoting the pin assembly 20 and a pivotally supported member.



The pin assembly 20 having the structure mentioned above is especially exposed to a great load in both the radial and thrust directions, and is preferably used in the pivoting apparatus of the bogie having the track roller of the track-type drive system in which a lot of dusts exist in the environment where the system is used. Fig. 3 is a schematic view of a structure in the case of being applied to the pivoting apparatus of the bogie.

The bogie is constituted by a track roller (not shown in Fig. 3), a first bogie link 8 pivoted to the track frame 1, and a second bogie link 23 pivoted to the first bogie link 8 and corresponding to a pedestal of the track roller. The pin assembly 20 is used for pivoting the first bogie link 8 to the track frame 1 and pivoting the second bogie link 23 to the first bogie link 8. Details are as follows.

The track frame 1 is swingably attached to both side portions of a vehicle (not shown). A bracket 7 having an inverted U-shaped cross sectional shape is protruded from right and left sides of a lower portion of the track frame 1. An opening for the pin assembly 20 is provided in the bracket 7. One end of the first bogie link 8 is fitted and inserted to the bracket 7 from a lower side. The first bogie link 8 has an inverted L-shaped side elevational shape, and is structured such that one end is pivoted by the bracket 7 and another end is pivoted by the second



bogie link 23. Accordingly, openings for the pin assembly 20 are provided in one end and another end.

The pin assembly 20 is integrally pressure inserted to the opening of the bracket 7 from an outer direction of the first bogie link 8. The first link 9 and the third link 11 correspond to the opening of the bracket 7, and the second cylinder 10 corresponds to the opening in one end of the first bogie link 8. Inner diameters of the respective openings are set such diameters as to be interference fitted to the outer diameters  $D_1$ ,  $D_2$  and  $D_3$  of the rings. As a result, the first ring 9 and the third ring 11 are fitted to the bracket 7, and the second ring 10 is fitted to the first bogie link 8.

The second bogie link 23 pivotally supports the track roller in one end and another end, and has an opening for the pin assembly 20 in a center portion therebetween. In Fig. 3, there is illustrated only a plate in a side portion of the second bogie link. In the same manner as the pivotally supported portion mentioned above, the pin assembly 20 is pressure inserted to the opening in another end of the link from an outer side of the first bogie link 8. In accordance with the pressure insertion, the first link 9 and the third link 11 of the pin assembly 20 are firmly attached to the first bogie link 8, and the second link is firmly fitted to the second bogie link 23.



In accordance with the present invention, since the contact portions between the first ring and the second ring and between the second ring and the third ring are each constituted by substantially one flat plane in the radial direction of the pin assembly, the lubricant easily circulates around the contact portions and the obstacle in lubrication is hard to be generated. Further, since only the sealing means is interposed in the slide portion while abolishing the spacer, and the ring and the pin are structured as the integral pin assembly, it is possible to easily assemble the pin assembly itself and assemble the pivotally supported portion.

The description mentioned above is given only of the specific embodiments in accordance with the present invention, and the present invention is not limited to the embodiments. The other aspects of the present invention which those skilled in the art can carry out by studying the drawings, the specification and the claims are included in the technical scope of the present invention.



WHAT IS CLAIMED IS:

1. A pin assembly for a track roller bogie of a track-type drive system, comprising:

a pin having a lubricant charging hole and a lubricant delivering hole delivering the lubricant from the lubricant charging hole to an outer peripheral portion in an inner portion thereof;

a first ring having a contact surface with said pin in one end so as to be firmly attached to the pin and having an outer diameter  $D_1$ ;

a second ring brought into contact with another end side of said first ring in an axial direction of the pin so as to be rotatably pivoted to the pin and having an outer diameter  $D_2$ ; and

a third ring brought into contact with another end side of said second ring in an axial direction of the pin so as to be firmly attached to the pin and having an outer diameter  $D_3$ ,

wherein a part of a ring end surface contacted among said first, second and third rings has an annular recess portion, and said annular recess portion consists of a sealing means between rings for sealing therebetween, and said outer diameters  $D_1$ ,  $D_2$  and  $D_3$  have a relation  $D_1 < D_2 < D_3$ .

2. A track-type drive system comprising:



a track roller bogie having a track frame, an idler, a sprocket, a carrier roller and a track roller and pivoted to said track frame; and

a crawler belt wound around them,

wherein the track roller bogie is pivoted to the track frame by the pin assembly as claimed in claim 1.

3. A track-type drive system comprising:

a track roller bogie having a track frame, an idler, a sprocket, a carrier roller and a track roller and pivoted to said track frame; and

a crawler belt wound around them,

wherein said track roller bogie is constituted by a first bogie link pivoted to the track frame, and a second bogie link pivoted to said first bogie link and to which the track roller is mounted, and

wherein said second bogie link is pivoted to said first bogie link by the pin assembly as claimed in claim 1.

4. The pin assembly according to claim 1, wherein the slide portion among said first ring, said second ring and said third ring is constituted by a slide contact surface with which each of the rings is directly contacted, and a seal surface of said sealing means in correspondence to each of the slide contact surfaces, and said slide contact surface and the seal surface form a substantially one flat



plane in a radial direction.

5. A track-type drive system comprising:

a track roller bogie having a track frame, an idler, a sprocket, a carrier roller and a track roller and pivoted to said track frame; and

a crawler belt wound around them,

wherein the track roller bogie is pivoted to the track frame by the pin assembly as claimed in claim 4.

6. A track-type drive system comprising:

a track roller bogie having a track frame, an idler, a sprocket, a carrier roller and a track roller and pivoted to said track frame; and

a crawler belt wound around them,

wherein said track roller bogie is constituted by a first bogie link pivoted to the track frame, and a second bogie link pivoted to said first bogie link and to which the track roller is mounted, and

wherein said second bogie link is pivoted to said first bogie link by the pin assembly as claimed in claim 4.



#### ABSTRACT OF THE DISCLOSURE

A track roller bogie is pivotally supported by a pin assembly, in which a spacer for receiving a thrust load is abolished and the thrust load is supported by outer rings of the pin assembly themselves. It makes possible to assemble a pin assembly easier and to elongate a service life of the track bogie.



## Declaration and Power of Attorney for Patent Application

### 特許出願宣言書及び委任状

### Japanese Language Declaration

### 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

PIN ASSEMBLY FOR TRACK ROLLER

BOGIE OF TRACK-TYPE DRIVE SYSTEM

上記発明の明細書はここに添付されているが、下記の箱がチェックされている場合は、この限りでない：

the specification of which is attached hereto unless the following box is checked:

☐ の下に出席され、  
この出願の米国出願番号またはPCT国際出願番号は、  
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の日に修正された出願（該当する場合）

☐ was filed on \_\_\_\_\_  
as United States Application Number or  
PCT International Application Number  
\_\_\_\_\_ and was amended on  
\_\_\_\_\_ (if applicable).

私は、上記の宣誓書によって修正された、特許請求範囲を含む上記明細書を検討し、且つ内容を理解していることをここに表明する。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編規則1.56に記載されている、特許権について虚偽な情報を開示する義務があることを認める。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.



**Japanese Language Declaration  
(日本語宣言書)**

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国外の国の少なくとも一カ国を指定している特許協力条約365(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

**Prior Foreign Application(s)  
外国での先行出願**

**Priority Not Claimed**

優先権主張なし



(Number) (番号)	(Country) (国名)
(Number) (番号)	(Country) (国名)
(Number) (番号)	(Country) (国名)

(Day/Month/Year Filed) (出願年月日)
(Day/Month/Year Filed) (出願年月日)
(Day/Month/Year Filed) (出願年月日)



私に、第35編米国法典119条(e)項に基づいて下記の米国外特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Day/Month/Year Filed) (出願日)
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(Application No.) (出願番号)	(Day/Month/Year Filed) (出願日)
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私は、下記の米国法典第35編120条に基づいて下記の米国外特許出願に記載された権利、又は米国外を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国外特許出願に開示されていない限り、その先行米国外出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application

(Application No.) (出願番号)	(Day/Month/Year Filed) (出願日)
(Application No.) (出願番号)	(Day/Month/Year Filed) (出願日)

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委任状: 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁理士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name(s) and registration number(s))

R. Eugene VarndeLL, Jr. - Reg. No. 29,728  
Debra Shoemaker - Reg. No. 47,941

書類送付先

Send Correspondence to:

VARNDELL & VARNDELL, PLLC  
106-A South Columbus Street  
Alexandria, VA 22314

直接電話連絡先: (名前及び電話番号)

Direct Telephone Calls to: (name and telephone number)

R. Eugene VarndeLL, Jr.  
(703) 683-9730

唯一または第一発明者名

Full name of sole or first inventor

MURAKAMI, Shota

発明者の署名

日付

Inventor's signature

Date

Shota Murakami

29/09/2003

住所

Residence

Hirakata-shi, Japan

国籍

Citizenship

JAPAN

私書箱

Post Office Address

c/o KOMATSU Ltd., Osaka Plant, Ueno 3-1-1,  
Hirakata-shi, Osaka, Japan 5731011

第二共同発明者

Full name of second joint inventor, if any

YOSHIDA, Tsuyoshi

発明者の署名

日付

Second inventor's signature

Date

T. Yoshida

29/09/2003

住所

Residence

Katano-shi, Japan

国籍

Citizenship

JAPAN

私書箱

Post Office Address

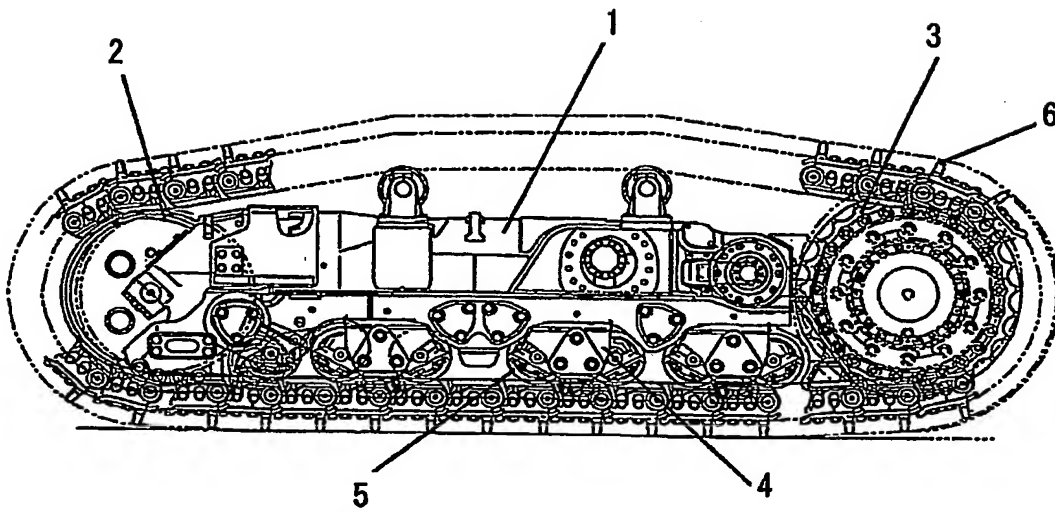
c/o KOMATSU Ltd., Osaka Plant, Ueno 3-1-1,  
Hirakata-shi, Osaka, Japan 5731011

(第三以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for third and subsequent joint inventors.)

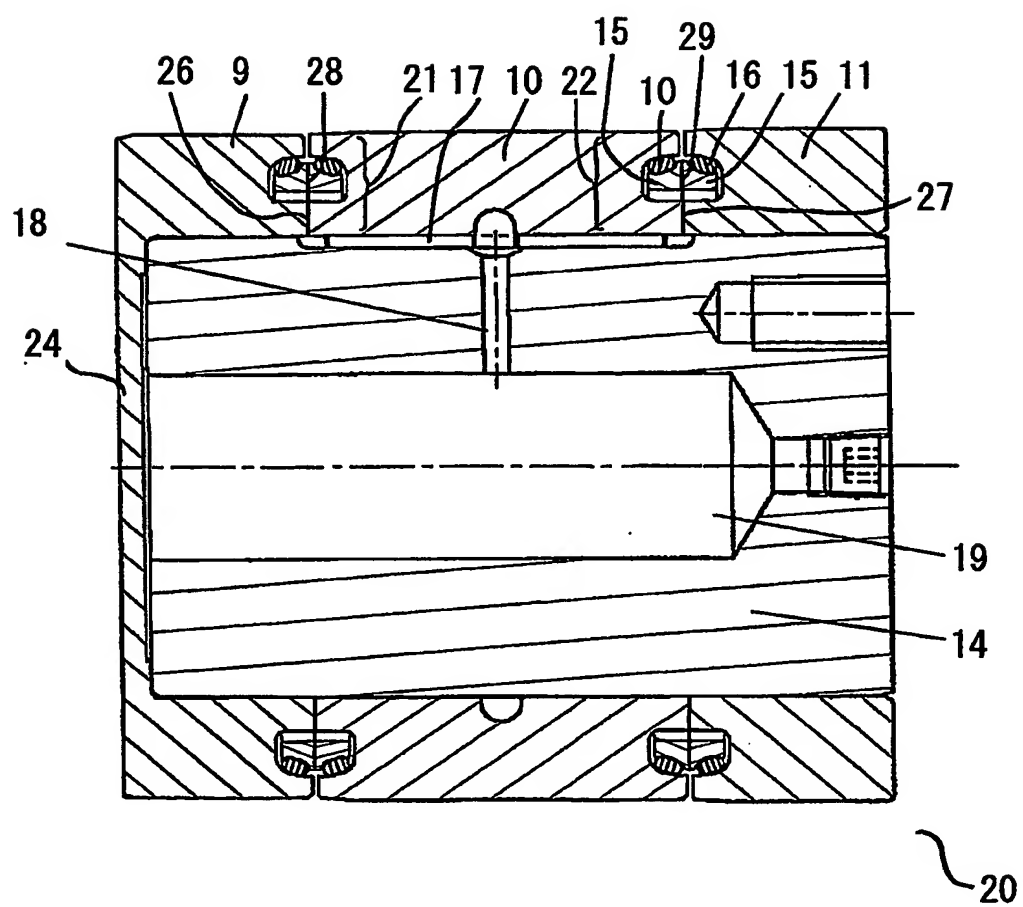


**Fig.1**



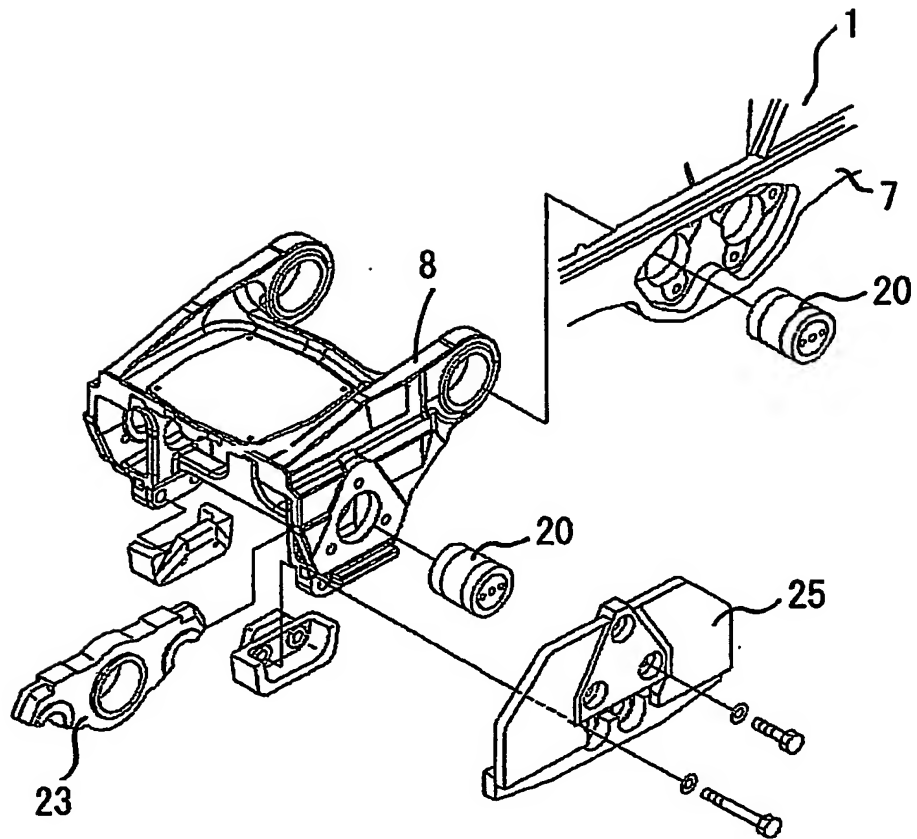


**Fig.2**



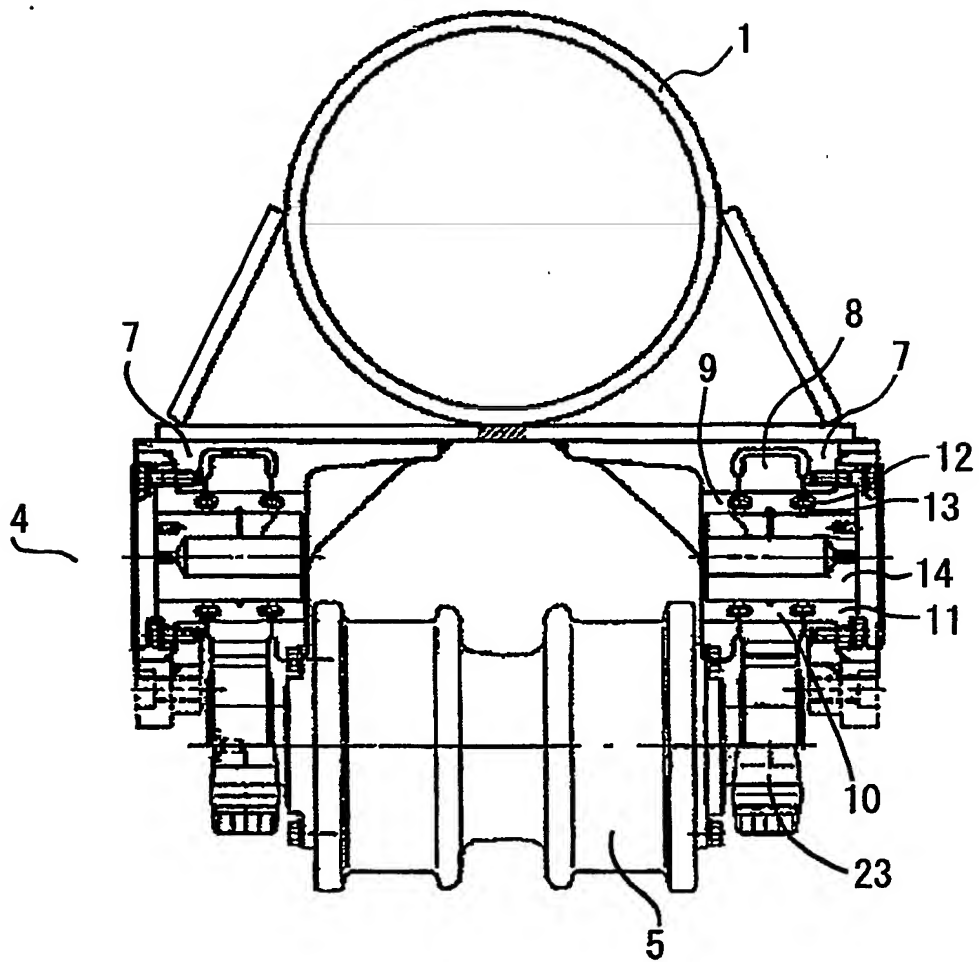


**Fig.3**



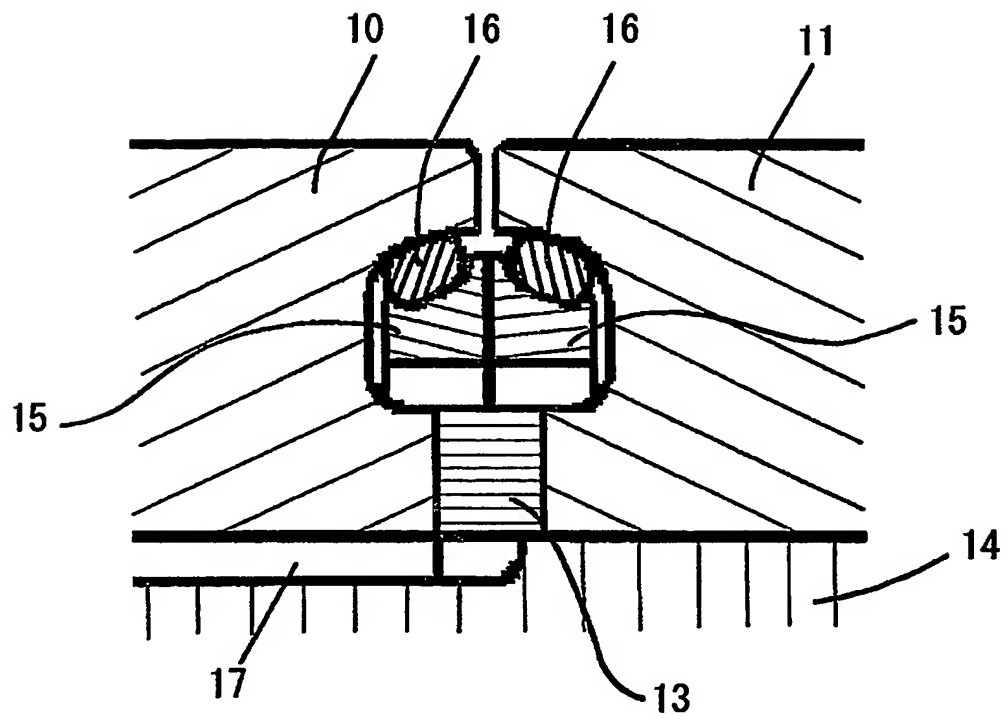


**Fig.4**  
**Prior Art**





**Fig.5**  
**Prior Art**





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